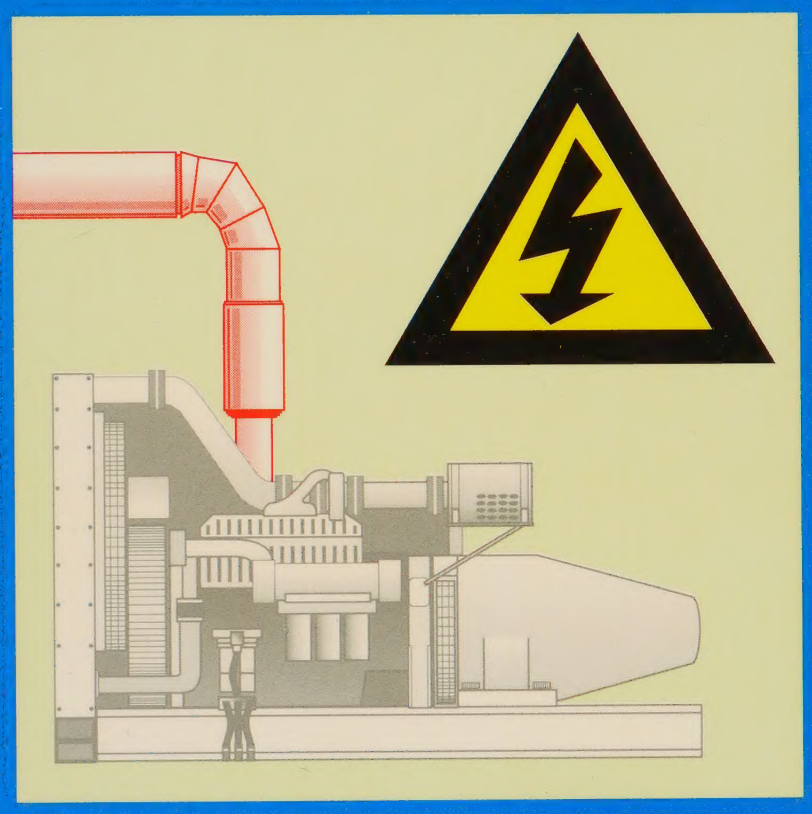
Health Technical Memorandum 2011

MC0184

Health Technical Memorandum 2011

Operational management

Emergency electrical services



UK Health Departments

NHS Estates
An Executive Agency of the Department of Health

Digitized by the Internet Archive
in 2025 with funding from
UCL Library Special Collections

https://archive.org/details/ucl_mc0184

Health Technical Memorandum 2011

Operational management

Emergency electrical services

London: HMSO

NHS Estates
An Executive Agency of the Department of Health

© Crown copyright 1992
Applications for reproduction should be made to HMSO
First published 1992

ISBN 0 11 321411 1

HMSO
Standing order service
Placing a standing order with HMSO BOOKS enables a customer to receive future titles in this series automatically as published. This saves the time, trouble and expense of placing individual orders and avoids the problem of knowing when to do so. For details please write to HMSO BOOKS (PC 13A/1), Publications Centre, PO Box 276, London SW8 5DT quoting reference 14 02 017.
The standing order service also enables customers to receive automatically as published all material of their choice which additionally saves extensive catalogue research. The scope and selectivity of the service has been extended by new techniques, and there are more than 3,500 classifications to choose from. A special leaflet describing the service in detail may be obtained on request.

About this publication

Health Technical Memoranda (HTM) give comprehensive advice and guidance on the design, installation and operation of specialised building and engineering technology used in the delivery of health care.

They are applicable to new and existing sites, and are for use at various stages during the inception, design, construction, refurbishment and maintenance of a building.

Health Technical Memorandum 2011

HTM 2011 focuses on the:

- legal and mandatory requirements;
- design applications;
- maintenance; and
- operation,

of emergency and essential electrical supply equipment in all types of health care and personal social services premises.

It is published as four separate volumes each addressing a specialist discipline:

- This volume – **Operational management** – provides information for those responsible for overseeing and operating day-to-day running and maintenance. Coverage includes stand-by generators, batteries, test runs and record keeping. Supplementary power for peak periods, and combined heat and power systems are also discussed;

- **Management policy** – outlines the overall responsibility of managers of health care and personal social services premises, and details their legal and mandatory obligations in setting up and operating a reliable emergency electrical supply. It summarises the technical aspects involved and concludes with a list of definitions;

- **Design considerations** – highlights the overall requirements and considerations that should be applied to the design up to the contract document;

- **Validation and verification** – details the requirements for ensuring that manufactured equipment is formally tested and certified as to contract and manufactured to the highest level of quality assurance. The importance of commissioning is emphasised and the order of tests on site is listed. Routine testing, which is a subset of these commissioning tests, is also reviewed.

Guidance in this Health Technical Memorandum is complemented by the library of National Health Service Model Engineering Specifications. Users of the guidance are advised to refer to the relevant specifications for "Emergency supply".

The contents of this Health Technical Memorandum in terms of management policy, operational policy and technical guidance are endorsed by:

- The Welsh Office for the NHS in Wales;
- The Health and Personal Social Services Management Executive in Northern Ireland;
- The National Health Service in Scotland Management Executive,

and set the required standards consistent with Departmental Cost Allowances.

References to legislation appearing in the main text of this guidance apply in England and Wales. Where references differ for Scotland and/or Northern Ireland these are given as marginal notes.

Where appropriate, marginal notes are also used to amplify the text.

Contents

About this publication

1.0 Scope *page 3*

2.0 Maintenance *page 4*
2.1 Spares
2.6 Tools
2.7 Instructions
2.8 Maintenance reports
2.10 Test runs
2.19 Engine coolants
2.23 Records
2.24 Servicing of batteries
2.27 Battery charging
2.40 Starting batteries

3.0 In-house generation *page 9*
3.1 Use of generators for peak load reduction or combined heat and power operation
3.5 Regional electricity company agreement
3.8 Electricity tariffs
3.12 Daily load and annual maximum demand pattern
3.14 Cost per unit generated
3.18 Size of generating set
3.21 Voltage regulation
3.23 Excitation and control
3.29 Instability – pole slipping
3.33 Governor control
3.37 Power factor correction

Other publications in this series *page 16*

About NHS Estates *page 17*

1.0 Scope

General

1.1 Health care and personal social services premises are totally dependent upon electrical power supplies, not only to maintain a safer and more comfortable environment for patients and staff, but also to give greater scope for treatment using sophisticated medical equipment at all levels of clinical and surgical care. Changes in application, design and statutory requirements have led to the introduction of a new generation of equipment and new standards of reliability.

1.2 Interruptions in electrical power supplies to equipment can seriously disrupt the delivery of health care with serious consequences for patient well-being. Health care and personal social services premises must therefore ensure that they can continue to provide electrical power to essential services in the event of prolonged or short disruption to supplies.

Emergency electrical services

1.3 Emergency electrical services form an integral part of the health care and personal social services premises supply network in meeting both safety and functional requirements. They can be in the form of batteries, uninterrupted power supply (UPS) systems, or stand-by generators.

1.4 The provision of emergency electrical services in health care and personal social services premises is a management responsibility at both new and existing sites. This guidance is equally applicable to premises which offer acute health care services under the Registered Homes Act 1984.

Nursing Homes and Agencies Act (Northern Ireland) 1971
Nursing Homes Regulations (Northern Ireland) 1974
Registered Establishments (Scotland) Act 1987

2.0 Maintenance

Spares

2.1 Modern diesel or gas engines are capable of extensive use between overhauls. Running times between overhauls will vary considerably with type of use and nature of the fuel oil or gas used. Typical running hours between overhauls are:

Emergency generator set duties	2,000 hours, 3 years maximum;
Combined heat and power (CHP) duties	
– diesel	6,000 hours short overhaul; 12,000 hours long overhaul;
– gas	12,000 hours short overhaul 30,000 hours long overhaul;

2.2 Generators will be capable of operating for several years when confined to an emergency generating role before cylinder and crankshaft overhaul is necessary. In these circumstances, the need for spares is limited.

2.3 For emergency generator sets co-opted into a combined heat and power role, the range of available spares should be extended.

2.4 In all cases the frequency of maintenance, that is servicing and overhaul, will be influenced by the quality of fuel and lubricating oils used and the pattern of operation.

2.5 The following spares list is suggested for equipment operating in an emergency role only:

a. one complete set of cylinder gaskets, special seals and packings etc;

b. one set of renewable parts for oil fuel and air inlet filters;

c. two complete cylinder fuel oil injectors;

d. one automatic voltage regulator (AVR) replacement unit;

e. one set of rotating diodes for brushless generators;

f. one set of engine control relays.

Tools

2.6 A complete set of high quality spanners and special tools required for servicing the emergency generator set by the hospital staff should be held in stock.

Instructions

2.7 Instructions for starting, stopping, operating and routine testing of the emergency generator set should be supplied by the manufacturer with each set as early as possible to assist in staff training. Planned preventive maintenance and servicing should be based on the Works Information Management System (WIMS) and the appropriate maintenance instructions provided by the manufacturer. Details of all sensors, electrical protection relay settings and control fuse sizes should be recorded for future reference.

Maintenance reports

2.8 Routine servicing instructions should be scheduled and a log-book kept of all work that is carried out, including details of any parts that are renewed with a brief note of any defects or failures and rectifying action taken.

2.9 The log-book should include details of any running of the emergency generator set, for example test runs, runs caused by mains failure or scheduled mains interruptions and maintenance purposes. It should include battery and charger histories and a weekly test of specific gravity and/or cell voltages.

Test runs

2.10 It is important that regular checks are made to ensure that the engine start-up is operational.

2.11 It is advisable to turn the engine over once weekly with the fuel isolated. This routine purges the cylinders of water deposits that may have entered from leaking gasket seals from the water jacket or water deposits condensed from previous running.

2.12 A no-load run of up to 15 minutes to test the reliability of the engine start up and the electrical control system should be carried out every two weeks. Extended running at no-load is not advised, as this encourages build up of carbon and mineral salt deposits around the engine inlet ports and fuel injectors. Bearing wear also occurs disproportionately owing to the lubricating oil not being rapidly or fully heated to operating temperature at the onset of a cold start-up.

2.13 Start-ups should be made by simulating loss of normal supply, and the total time to start up the engine and re-establishing normal supply recorded.

2.14 No-load stops should be made as variable as possible to proof test and demonstrate the operation of the various protective mechancial sensors and electrical protection relays.

2.15 Loads in excess of 70% full load should be sought for periods of at least two hours on a monthly basis. Operational runs at or near full load help to remove carbon desposits accumulated during the no-load runs. The load may be obtained by the hire of a load bank, synchronising to the supply where agreements exist with the regional electricity company, or linking the essential and non-essential loads by a coupler device.

2.16 The overspeed governor shall be operated on a monthly basis, prior to the load test. This is carried out when the generator set is operating at **no load** and the circuit breaker is open. The method to overspeed the engine will depend on whether the governor is hydraulically or electroncially controlled and adapted for single or parallel running. The manufacturer's guidance should be sought.

2.17 Trip tests on load should only be attempted at loads less than 25% full load. An attendant should be ready to close the fuel rack in the event of failure of the governor trip linkage. On conclusion of load tests, engines should be allowed to run for five minutes at no-load before final shutdown to assist natural cooling of the engine and remove cylinder hot spots resulting from sudden load shut-down.

2.18 Ear muffs must be worn by attendants while engine running operations are in progress.

Engine coolants

2.19 Regular checks of the cooling radiator fluid are required to ensure there is sufficient anti-freeze and corrosion inhibitor and that no fluid leakages have occurred.

2.20 The engine jacket and secondary cooling water should be distilled, ion exchange demineralised or potable water with minimal chalk or lime solids in solution and be non-acidic (pH 8 to pH 10.5). The cooling water should be treated with an anti-freeze solution containing corrosion inhibitor, either of the ''universal'' type, having an ethylene glycol base, or one conforming to BS4959. The anti-freeze to water mixture proportions needed will depend upon the minimum freezing temperature against which protection is required and to ensure adequate corrosion inhibitor is present to protect all metal parts in the cooling system.

2.21 For full protection in the UK a 40% volume (35% minimum to 50% maximum) anti-freeze solution, with suitable multi-purpose additives, should be added to the jacket and radiator cooling water. The advice of the manufacturer should be followed as to the installation and period of use of anti-freeze solutions.

2.22 Under no circumstances should methanol-based anti-freeze solutions be used. These have a high evaporation rate at normal engine temperatures and will lead to rapid loss of coolant.

Records

2.23 A log-book record of all test runs and specific tests carried out on the emergency generator set to demonstrate its reliability must be kept and stored in a safe place. All failures and defects noted should be recorded and a record kept of all "defect report notices" issued and maintenance correction work carried out to reinstate defective items of equipment.

Servicing of batteries

2.24 Regular servicing of battery equipment by competent personnel is essential. A large proportion of failures in emergency supplies associated with luminaires and engine starts can be attributed to battery neglect, the purchase of unsuitable batteries or incorrect interpretation of battery test results.

2.25 BS5266 Part 1: 1988 – 'Emergency Lighting' is a code of practice and contains a detailed list of routine servicing to emergency batteries. This document should be used as an essential guidance reference in conjunction with the battery and charger manufacturers' maintenance manuals.

2.26 Routine servicing should be carried out to varying degrees on the following basis:

- daily;
- monthly;
- six-monthly;
- three-yearly;
- subsequent annual tests applicable to batteries supplying self-contained luminaires.

Battery charging

2.27 The battery charger should be capable of maintaining the battery in a healthy state during long periods of non-use and of automatically recharging it to a fully charged state in the safest and shortest practicable time after use. Insufficient charge current may result in the battery becoming derated in capacity. Excess charge current can cause evaporation of electrolyte and extra internal corrosion to the plates and connecting bars. A lead-acid battery trickle charge current should maintain full charge without gassing and a constant specific gravity of 1.2 at 2.25V per cell. In general, a lead-acid battery trickle charge current of one milliampere per ampere-hour of 10-hour capacity is sufficient when new. As the battery ages, the trickle charge current may be increased up to three milliamperes per ampere-hour of 10-hour capacity.

2.28 Alkaline batteries should be continuously trickle charged and the voltage should be set at 1.45V per cell, temperature corrected and controlled. The loss of charge is minimal, and hence the trickle recharge current is very small. Boost charging at 1.6/1.7V per cell, at 6 to 12 monthly intervals, is beneficial after previous routine maintenance discharge. This operation must be continuously supervised by an attendant.

Where batteries are charged at constant voltage the maximum charge current recommended by the manufacturer must not be exceeded.

In the constant current mode, the applied voltage has to rise to maintain constant current throughout the recharge process, and will necessitate higher voltage levels per cell as the battery internal resistance increases with age.

2.29 There are two nominal methods of recharging a partially or fully discharged battery, namely at constant current or at constant voltage, the latter also being known as "taper charge". The essential requirement is to ensure that all battery cells are equally charged to their maximum capacity. The current required to obtain this minimum level of charge is known as the "equalising charge current". If the charge current is not sufficient, not all the cells will be fully or equally charged. If the charge current is excessive, electrolyte will be lost by evaporation and the cell plates and bars may be damaged by overheating and corrosion. Alkaline batteries are more suited for constant current charging. The general practice is that all types of batteries are charged at constant voltage to suit the required operating mode.

2.30 Batteries must be recharged at current/time values recommended by the manufacturer.

2.31 A range of portable battery test equipment is available from specialist manufacturers.

2.32 Recombination batteries, when subject to excessive charge current, are unable to recombine all the generated hydrogen and oxygen. A gas excess pressure occurs and can result in the lifting of the battery pressure relief valve (at typically 1psi (7kPa)) and loss of hydrogen and oxygen gas to the atmosphere. This is ultimately a loss of irreplaceable electrolyte, which will result in a shortening of battery life. This type of battery is not as resilient as open-vented batteries during charging, owing to the smaller quantity of electrolyte present to quench internal short-circuit electrical faults if they occur.

2.33 Battery chargers are now of solid-state rectifier design. There must be adequate control for recharging currents within the manufacturer's recommended current/time range. Unregulated mains voltage fluctuations may significantly affect the state of battery charge, where the charger is provided with too close voltage/temperature control limits.

2.34 Instrumentation should be adequate and indicate mains and battery output voltage as well as charging and output currents. Battery ripple current should be limited to a maximum range of 7.5% to 10%, based upon manufacturer's recommendations. Extra costs in charger and uninterruptible power supply (UPS) equipment can be incurred if low level ripple is over-specified.

2.35 Batteries for luminaires and engine starting should be recharged immediately after use. An initial high recharge rate at constant current is acceptable for alkaline and lead-acid batteries, with a tapering transfer to a trickle charge when fully recharged.

2.36 Alkaline and lead-acid batteries must be kept topped up with approved distilled or ion exchange demineralised water at the correct levels at all times to prevent plate damage. A routine of maintenance of a good standard using the battery and charger manufacturer's instructions must be followed.

2.37 In a UPS, the total input with the battery on float charge can exceed the output load by 25% when battery recharging commences after a period of battery emergency supply operation. A large additional battery recharge load should not be imposed on the AC emergency generator set when operationally undesirable. This battery recharging load may be delayed or kept disconnected from the UPS charger by selective switching control and the energy left available for priority essential supplies until a more settled supply prevails.

2.38 Batteries in low temperature environments will require higher battery charger voltages to effect the same rate of current charge, and vice versa. Where low or high temperatures occur, voltage/temperature compensation should be used in the charger.

2.39 Manually controlled battery charging is not recommended except under specially controlled and supervised operations.

Starting batteries

2.40 Engine starting batteries should be of an approved type, regularly checked and maintained fully charged. Automotive batteries are not recommended to be used for any emergency use. The charger should be regularly checked to ensure that the trickle current recharge rate is correct. The engine battery should be well ventilated to allow hydrogen/oxygen gases to disperse. This requirement is particularly applicable to lead-acid batteries operating at high trickle charge currents. See HTM 2011, Emergency electrical services, 'Design considerations', Section 6.

3.0 In-house generation

Use of generators for peak load reduction or combined heat and power operation

3.1 Emergency engine-driven generators provided as a safeguard against loss of normal supply are likely to receive limited use for this purpose, and the possibility of using the equipment for peak lopping (peak load reduction) may be investigated. However, such use should be carefully considered, as the effectiveness of their primary function may be compromised. It is important to ensure that the emergency generating sets are always available for providing essential supplies in the event of the unexpected loss of normal supplies. The running hours of an engine-driven emergency generator set should be restricted to prevent a major overhaul being required before a period of three years has expired.

3.2 Peak lopping or CHP operation presupposes that the generating plant is capable of, and equipped for, running in parallel with the regional electricity company. The engineering requirements are laid down by the Electricity Association as guidance in 'Recommendations for the Connection of Private Generating Plant to the Electricity Boards' Distribution Systems' – Engineering Recommendation G.59: 1985 and subsequent revisions and amendments.

3.3 An alternative to having generators in parallel with the normal mains supply is to arrange for an emergency generator to supply the essential supplies separately during peak demands to obtain more economic and efficient operation. This eliminates synchronising, system stability problems and fault current rating levels. Auto change-over switching would be necessary and should be delayed until the engine has reached an operating condition for the generator to be loaded.

3.4 The factors affecting economic viability that influence the decision whether peak lopping or CHP electrical power export uses are feasible are:

a. agreement of the regional electricity company to issue a suppliers' licence;

b. electricity tariff charges depending on the optimum point of export of power in relation to a nominated consumer;

c. daily load patterns and the annual load factor for private generation;

d. cost per unit generated and standing charge;

e. a variable system charge influenced by the reliability, size and number of private generating sets in relation to the regional electricity companies' statutory requirement to maintain an available supply for consumers in the event of failure of the private generation;

f. ability and experience of staff;

g. cost of additional generator control and protection required by the regional electricity company;

h. provision of an indemnity to the regional electricity company in the event of damage to other consumers' equipment.

Regional electricity company agreements

3.5 Unless technical grounds make it impracticable, a regional electricity company must make an offer following a request from a private generator or supplier as required in the provisions of the Energy Act 1983 and Electricity Act 1989:

Electricity (Northern Ireland) Order 1991
Electricity (Northern Ireland) Requirements Order 1991

a. for a supply to his premises;

b. to purchase electricity generated by him; or

c. permit him to use the regional electricity company system to provide a supply to any premises.

3.6 It is essential to carry out close consultation with the regional electricity company at the earliest possible time before embarking on any detailed investigations. The primary technical considerations are:

a. parallel operation of generators for electrical power export to the public supply can introduce voltage and instability hazards to the regional electricity company and health care and personal social services premises electrical systems;

b. if export of electrical power is limited by agreement then a reverse power or directional overcurrent relay needs to be fitted to the supply feeder to prevent the export of power above a set level by automatically opening the circuit-breaker on the supply transformer feeder;

c. additional electrical protection such as definite time directional overcurrent, rate of change of frequency relay and/or reactive export error detector, under voltage relays, will be required at the supply transformer circuit-breakers to instantaneously separate the systems. This is especially important in the event of a failure in the regional electricity company system due to an auto reclose switching transient or blackout;

d. the rating of and export from the generators will be subject to licence and must be regulated automatically or by an operator to minimise the export or import of reactive power between the two systems or between generators, if more than one is operated. This is particularly important if one of the generators is an induction generator;

e. the neutral earthing must comply with Electricity Supply Regulations (1988) No 1057, Part 2, for HV and LV generation. Neutral earth switching will be required to ensure that each generator can be disconnected at the star point from earth whilst running in parallel with the supply. When in parallel and separated from the regional electricity company system, only one running synchronous generator neutral shall be connected to earth;

Electricity Supply Regulations (Northern Ireland), SI 1991/536 (NI)

f. larger rated switching devices and cable sizes for increased fault current ratings may be required;

g. at all times whilst the generator is connected to the regional electricity company system, an authorised person, approved by the regional electricity company, may be required to be in attendance to regulate the active and reactive power and to maintain generator stability, and also to carry out switching functions required by the regional electricity company, if not under their direct remote control.

3.7 In general, regional electricity companies, since the Energy Act 1983, do not discourage small (less than 200/300kW) peak lopping schemes in parallel operation.

Electricity (Northern Ireland) Order 1991

Electricity tariffs

3.8 Each regional electricity company has its own scale of charges for electricity, and most tariffs applicable to hospitals include a maximum demand charge based on twice the maximum number of units supplied during any 30 consecutive minutes within a defined period.

3.9 The tariffs most satisfactory for peak lopping schemes have a monthly maximum demand rate which varies from a maximum in winter to a minimum in seven summer months. With this tariff, generating plant need only operate up to 2,000 hours per year from 1 November to 31 March during the times of excess maximum demand in the health care and personal social services premises load.

3.10 For peak lopping or CHP schemes the regional electricity companies will normally make an additional charge for holding available the necessary standby generating capacity (spinning reserve). This reserve is for use in the event of breakdown and for maintenance of all or part of the private generating plant. The charge is normally expressed in a special tariff as a system availability charge, negotiated with the consumer. Availability charges will have an important influence on the overall economics of peak lopping and CHP systems.

3.11 A pre-set maximum demand relay may be necessary to give advance warning to the operator to start the emergency generator for synchronising to the normal mains supply or to shut down when no longer required.

Daily load and annual maximum demand pattern

3.12 When investigating the possibilities of on-site generation for peak load reduction it is necessary to obtain in as much detail as possible the daily, monthly and annual profiles of the health care and personal social security premises' electrical demands. For existing health care and personal social services premises past electricity bills will provide the most useful source of information, but for projected premises outline estimates should be used. The economic possibility of peak lopping will not be worthwhile investigating unless the health care and personal social services premises has a peaked load curve which occurs during the winter when the total national load is greater and, hence, when a substantial part of the electricity bill comprises maximum demand charges. The most convenient method to adopt is to calculate the annual load factor. Generally peak lopping is attractive for load factors under 30%:

$$\text{Load factor} = \frac{\text{Total power consumed in year/period}}{\text{Total power that could be generated in year/period}}$$

3.13 Close attention to methods of improving the annual load factor may be more economically advantageous than peak lopping.

Cost per unit generated

3.14 The cost per unit generated will usually exceed the unit charge of the regional electricity company and accordingly the generator should only be used for the periods necessary to achieve the most economic reduction in the maximum demand charge.

3.15 In determining the cost per unit generated it is necessary to take into account the annual plant amortisation cost as well as the additional costs of fuel, lubrication, labour and maintenance.

3.16 With peak lopping, consideration must be made that the plant was provided for emergency purposes only. It is, therefore, reasonable to assume that the additional cost is related only to such items that involve the additional plant use for peak lopping. This will include such items as bulk fuel storage facilities, synchronising and protection equipment, additional switchgear, contract maximum demand meter etc that are wholly related to parallel running with the regional electricity company supply. If peak lopping entails supplying the designated essential supplies during periods of maximum demand only, these essential supplies being provided entirely from the AC emergency generator, then the additional costs would relate to larger capacity fuel oil tanks and the increased maintenance and labour charges to maintain the additional supply.

3.17 For estimating purposes a typical cost per unit generated should be taken as equal to "W" pence, based on fuel oil prices of "X" pence per litre and lubricating oil prices of "Y" pence per litre and a figure of "Z" pence per unit for the reduced life of the AC emergency generator set, where W = X + Y + Z.

Size of generating set

3.18 As previously stated, regional electricity companies do not discourage small peak lopping schemes in parallel with their systems. It should be borne in mind that the additional cost to adapt small plant to peak lopping may not be directly proportional to the size of the plant. This is particularly so when parallel running of generating plant is being considered. Consequently, it is doubtful whether generating sets of less than 250kW rating for peak lopping would be economically advantageous.

3.19 Under the Electricity Act 1989, anyone who generates, transmits or supplies electrical energy will require a licence, unless exempted. Exemption applies to generating sets of less than 10MW rating and exporting suppliers below 500kW. Existing independent generators (as at 1989) were not required to be licensed.

Electricity (Northern Ireland) Requirements Order 1991

3.20 Where two or more emergency generating sets are considered, it is important that they are suitable for parallel operation. The existing cables and switchgear should have sufficient fault current ratings and be protected to withstand fault currents that may occur when two or more sets operate in parallel or, more importantly, run in parallel with the regional electricity company's normal mains supply.

Voltage regulation

3.21 The generator terminal voltage should be automatically maintained to within ±2.5% of the rated voltage at any load, from no load to 10% overload, between unity and 0.8 power factor (lagging). The droop in the AVR-controlled voltage should be substantially similar for all generators.

3.22 After a change in load from zero to 60% the voltage should not vary by more than ±15% of the rated voltage and should return to within ±3% within 0.5 seconds. On starting, the voltage overshoot should not exceed 15% and should return to within ±3% in not more than 0.15 seconds. The manual trim controller should be able to adjust the AVR-controlled generator terminal voltage to within ±15% of nominal limits.

Excitation and control

3.23 A single AC generator running at a constant governor-controlled speed and not connected to the regional electricity company supply will have current and power factors, at the rated voltage, determined by the impedance characteristic of the load.

3.24 When AC generators are running in **parallel**, whether connected to the regional electricity company supply or not, a continuous interaction occurs between the governors and the AVRs of AC generators, which if not regulated may eventually lead to dynamic instability in a generator operating at or near its rated output.

3.25 The excitation field current can be increased or reduced by manual adjustment of the manual trim controller, even under "auto" control. In parallel with other generators and, to a greater extent, with the regional electricity company supply, field current adjustment not only varies the voltage generated at the generator switchboard, but also causes a redistribution of inductive reactive power load between the other parallel generators. This results in changes to the load currents and power factors of each generator and the supply transformer, that is, the incoming supply. Any small changes in the field current by a generator manual trim controller should be immediately counterbalanced by small opposite adjustments in the manual trim controllers of the other parallel generators. An excessive reduction in field current can cause instability and loss of synchronism in an AC generator near or at full load. Likewise, an increase exceeding the maximum field current will cause generator rotor overheating and also reduce the stability margins in adjacent parallel generators.

3.26 In a system of balanced governor control and parallel running generators, improved stability and load sharing can be obtained by an AVR element of auto-control which responds to the summation of the reactive or quadrature vector components in each generator load current. This unified control mode, known as the "parallel mode", can be individually selected at each generator control panel.

3.27 Generators are normally provided with an "auto" and a "manual" follow up mode of excitation control. If failure to the "auto" mode occurs, the excitation trips to the "manual" mode. When a generator is operating in the "manual" mode the control of the terminal voltage is no longer responsive to a change in system voltage, nor is it able to maintain the desired terminal voltage. This can indirectly hazard the stability of a generator when connected in parallel to the normal system or other generators. Generators selected to "manual" mode of excitation control must not be left unattended.

3.28 Control of running generating plant must only be exercised by adequately trained "authorised" or "competent" persons.

Instability – pole slipping

3.29 Instability in a generator occurs when the rotor main field DC current is not of sufficient magnitude to maintain a secure magnetic field linkage between the rotor DC field and the stator AC contra-rotating field, at a specific engine input torque. This means that the input torque can sever the fixed relationship between the rotor speed and the stator magnetic field rotation. The rotor speed will increase above the pole pair related synchronous speed.

3.30 A fast relative rise in speed will result in the trip of the generator owing to operation of the field current, stator current or voltage protection devices. For small generators, a slow relative rise in speed will not cause an immediate generator loss, but will be seen on the instrumentation as a fluctuation in voltage and current in the generators and the whole neighbourhood supply system.

3.31 For practical purposes, the generator with the instrumentation readings fluctuating in the opposite direction to the others is the unstable generator. This will not be apparent with only one or two generators on load. A less than normal main field excitation current and a leading power factor are indications.

3.32 To regain stability in such marginal operating circumstances, the field current must be immediately increased, and/or the generated output reduced sufficiently to a level to remove the generator instability and prevent an imminent trip of the generator. A sudden change in the voltage, power factor and field current in other parallel connected generators must be concurrently observed and corrected.

Governor control

3.33 The scope of a governor to regulate the supply of fuel to an engine, and hence the output from an AC generator, depends on its sensitivity in opening or closing the fuel rack. Any outside cause to change the generator speed, for example, the governor-set synchronous speed, or any speeder motor adjustment applied to the governor setting, is equivalent to a change in the electrical load demand or output required.

3.34 The governor overall control and speeder motor control function jointly to regulate the speed in single running. They automatically maintain the speed at the selected load, within a speed range of 100% to 95% and a load range of no-load to full-load respectively, that is, the governor speed characteristic:

a. in **single** running, a speeder motor auto control may be required with isochronous speed control to maintain constant speed and hence constant frequency of supply with changing load demand;

b. in **parallel** running, as described above for single running, the governor and speeder motor controls function jointly. The governor is now tied to the fluctuation of the system frequency, at a selected generator output.

3.35 A rise in system frequency will initiate the governor to close the engine fuel rack, to reduce the generator output, and similarly a fall in system frequency will further open the fuel rack, if not already fully open, and attempt to increase the generated output. This functions within the range of the governor speed characteristic, over the speed range of 100% to 105% synchronous speed, giving a load change from full load to no load respectively.

3.36 From no load to 110%, the governor should be stable and sensitive, and respond to prevent overspeed excursions reaching 110%. If a speed of 110% is reached, the governor overspeed protection closes the engine fuel rack, cutting off the fuel supply to the engine.

Power factor correction

3.37 Power factor correction (PFC) units have capacitive reactive power outputs and are installed to compensate for excessive inductive reactive power demand. These may overcompensate when in circuit with generating plant. The net result of overcompensation will be seen as a higher than normal supply voltage and a

leading power factor. The PFC unit should be isolated from circuit if not reliably and automatically controlled.

3.38 A generator AVR will reduce the supply voltage, and hence the generated inductive reactive power, to reduce any PFC overcompensation. The indicated power factor will increase towards unity or to a leading power factor. This change in power factor indicates a generator is operating in a less stable operating region.

3.39 In situations where PFC overcompensation may occur, audible alarms to indicate minimum field excitation current for the generator should be provided. The additional option of automatic field excitation current "forcing" at the minimum field excitation current to maintain generator synchronism should be provided on larger generators.

Other publications in this series

(Given below are details of all Health Technical Memoranda available from HMSO. HTMs marked (*) are currently being revised, those marked (†) are out of print. Some HTMs in preparation at the time of publication of this HTM are also listed.)

1 Anti-static precautions: rubber, plastics and fabrics*†
2 Anti-static precautions: flooring in anaesthetising areas (and data processing rooms)*, 1977.
3 –
4 –
5 Steam boiler plant instrumentation†
6 Protection of condensate systems: filming amines†
7 Electrical services: supply and distribution*†
8 –
9 –
10 Sterilizers*†
12 –
13 –
14 Abatement of electrical interference*†
15 Patient/nurse call systems†
16 –
17 Health building engineering installations: commissioning and associated activities, 1978.
18 Facsimile telegraphy: possible applications in DGHs†
19 Facsimile telegraphy: the transmission of pathology reports within a hospital – a case study†
20 Electrical safety code for low voltage systems (in preparation)
21 Electrical safety code for high voltage systems*†
22 Piped medical gases, medical compressed air and medical vacuum installations*†
22 Supp. Permit to work system: for piped medical gases etc†
23 Access and accommodation for engineering services†
24 –
25 –
26 Commissioning of oil, gas and dual fired boilers: with notes on design, operation and maintenance†
27 Cold water supply storage and mains distribution* [Revised version will deal with water storage and distribution], 1978.
28 to 53 –

Component Data Base

54 User manual, 1989.
55 Windows, 1989.
56 Partitions, 1989.
57 Internal glazing, 1989.
58 Internal doorsets, 1989.
59 Ironmongery, 1989.
60 Ceilings, 1989.
61 Flooring, 1989.
62 Demountable storage systems, 1989.
63 Fitted storage systems, 1989.
64 Sanitary assemblies, 1989.
65 Signs†
66 Cubicle curtain track, 1989.
67 Laboratory fitting-out (in preparation)
68 Ducts and panels for sanitary assemblies (in preparation)
69 Protection (in preparation)
70 Fixings (in preparation)
71 to 80 –

Firecode

81 Firecode: fire precautions in new hospitals, 1987.
82 Firecode: alarm and detection systems, 1989.
83 Fire safety in health care premises: general fire precautions*†
84 Fire precautions in new residential care premises (in preparation)
85 [Revision to Home Office draft guidance in preparation]
86 Firecode: Assessing fire risks in existing hospital wards, 1987.
87 Firecode: textiles and furniture, 1987.
88 Fire safety in health care premises: guide to fire precautions in NHS housing in the community for mentally handicapped/ill people, 1986.

New HTMs in preparation

Lifts
Mains signalling
Legionnaires Disease
Telecommunications
Washers for sterile production
Special ventilation systems
Risk management and quality assurance

Health Technical Memoranda published by HMSO can be purchased from HMSO Bookshops in London (post orders to PO Box 276, SW8 5DT), Edinburgh, Belfast, Manchester, Birmingham and Bristol or through good booksellers. HMSO provide a copy service for publications which are out of print; and a standing order service.

Enquiries about Health Technical Memoranda (but not orders) should be addressed to:
NHS Estates, Department of Health, Room 313,
Euston Tower, 286 Euston Road, London NW1 3DN.

About NHS Estates

NHS Estates is an Executive Agency of the Department of Health and is involved with all aspects of health estate management, development and maintenance. The Agency has a dynamic fund of knowledge which it has acquired during 30 years of working in the field. Using this knowledge NHS Estates has developed products which are unique in range and depth. These are described below.

NHS Estates also makes its experience available to the field through its consultancy services.

Enquiries should be addressed to: NHS Estates, Euston Tower, 286 Euston Road, London NW1 3DN. Telephone: 071-388 1188.

Some other NHS Estates products

Activity DataBase – a computerised system for defining the activities which have to be accommodated in spaces within health buildings. *NHS Estates*

Design Guides – complementary to Health Building Notes, Design Guides provide advice for planners and designers about subjects not appropriate to the Health Building Notes series. *HMSO*

Estatecode – user manual for managing a health estate. Includes a recommended methodology for property appraisal and provides a basis for integration of the estate into corporate business planning. *HMSO*

Capricode – a framework for the efficient management of capital projects from inception to completion. *HMSO*

Concode – outlines proven methods of selecting contracts and commissioning consultants. Both parts reflect official policy on contract procedures. *NHS Estates*

Works Information Management System – a computerised information system for estate management tasks, enabling tangible assets to be put into the context of servicing requirements. *NHS Estates*

Option Appraisal Guide – advice during the early stages of evaluating a proposed capital building scheme. Supplementary guidance to Capricode. *HMSO*

Health Building Notes – advice for project teams procuring new buildings and adapting or extending existing buildings. *HMSO*

Health Guidance Notes – an occasional series of publications which respond to changes in Department of Health policy or reflect changing NHS operational management. Each deals with a specific topic and is complementary to a related Health Technical Memorandum. *HMSO*

Encode – shows how to plan and implement a policy of energy efficiency in a building. *HMSO*

Firecode – for policy, technical guidance and specialist aspects of fire precautions. *HMSO*

Nucleus – standardised briefing and planning system combining appropriate standards of clinical care and service with maximum economy in capital and running costs. *NHS Estates*

Concise – software support for managing the capital programme. Compatible with Capricode. *NHS Estates*

Items noted "HMSO" can be purchased from HMSO Bookshops in London (post orders to PO Box 276, SW8 5DT), Edinburgh, Belfast, Manchester, Birmingham and Bristol or through good booksellers. Details of their standing order service are given at the front of this publication.

Enquiries about NHS Estates products should be addressed to: NHS Estates, The Publications Unit, Department of Health, Room 540, Euston Tower, 286 Euston Road, London NW1 3DN.

NHS Estates consultancy service

Designed to meet a range of needs from advice on the oversight of estates management functions to a much fuller collaboration for particularly innovative or exemplary projects.

Enquiries should be addressed to: NHS Estates, Room 335 (address as above).

Printed in the United Kingdom for HMSO.
Dd 295514 C15 10/92 17647

Health Technical Memorandum 2011

Emergency electrical services
Operational management

NHS Estates

HMSO

Department of Health

Scottish Office

Welsh Office

Department of Health
and Social Services
Northern Ireland

Health Technical Memorandum 2011 gives comprehensive advice and guidance on the design, installation and operation of emergency electrical services.

It is published as four separate volumes.

This volume – 'Operational management' – provides information for those responsible for overseeing and operating day-to-day running and maintenance. Coverage includes stand-by generators, batteries, test runs and record keeping. Supplementary power for peak periods, and combined heat and power systems are also discussed.

HMSO

HMSO publications are available from:

HMSO Publications Centre
(Mail, fax and telephone orders only)
PO Box 276, London, SW8 5DT
Telephone orders 071-873 9090
General enquiries 071-873 0011
(queuing system in operation for both numbers)
Fax orders 071-873 8200

HMSO Bookshops
49 High Holborn, London, WC1V 6HB
(counter service only)
071-873 0011 Fax 071-873 8200
258 Broad Street, Birmingham, B1 2HE
021-643 3740 Fax 021-643 6510
Southey House, 33 Wine Street, Bristol, BS1 2BQ
0272 264306 Fax 0272 294515
9-21 Princess Street, Manchester, M60 8AS
061-834 7201 Fax 061-833 0634
16 Arthur Street, Belfast, BT1 4GD
0232 238451 Fax 0232 235401
71 Lothian Road, Edinburgh, EH3 9AZ
031-228 4181 Fax 031-229 2734

HMSO's Accredited Agents
(see Yellow Pages)

and through good booksellers

HMSO D

ISBN 0-11-321411-1

9 780113 214112